Electrical Machine Design – I (170902)

Design of Current Transformer

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Introduction

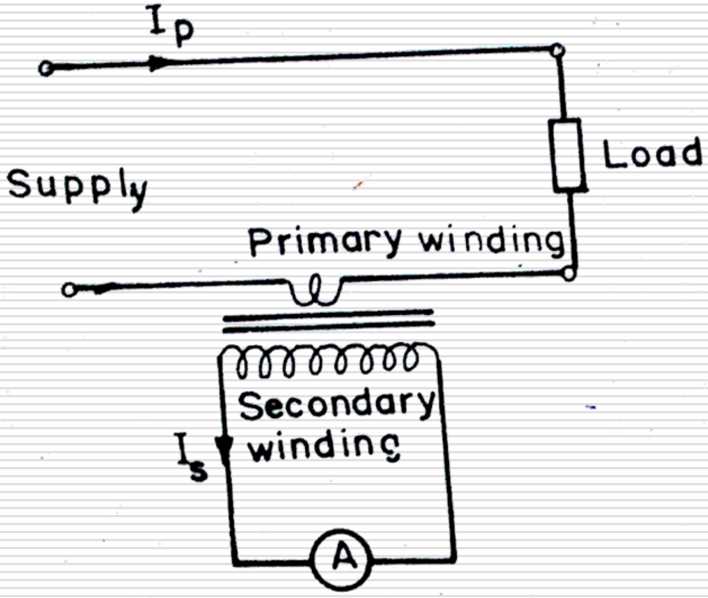


Fig. 10.1. Current transformer.

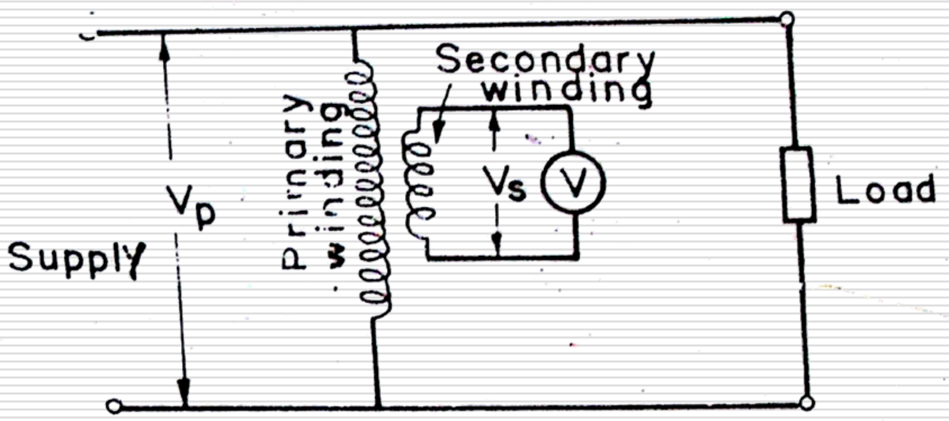


Fig. 10.2. Potential transformer.

Errors in CT

- **Transformation Ratio (R):**

$$R = \frac{\text{Pri. Winding Current}}{\text{Sec. Winding Current}}$$

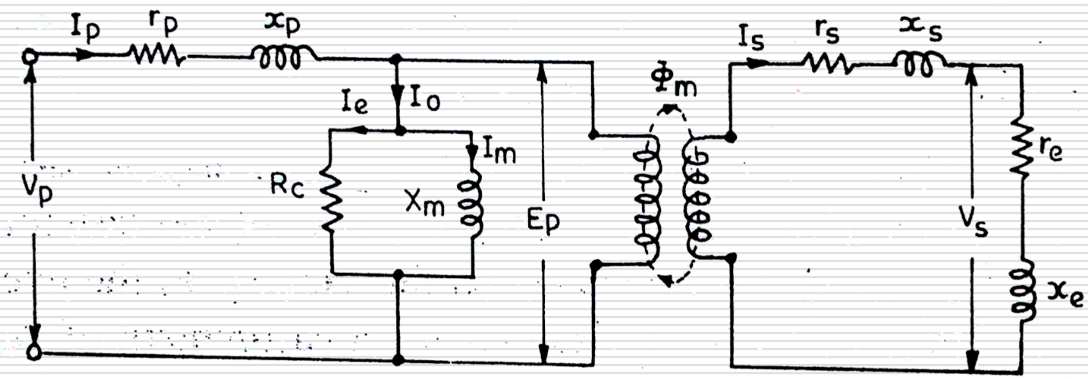
- **Turns Ratio (n):**

$$n = \frac{\text{Sec. Winding Turns}}{\text{Pri. Winding Turns}}$$

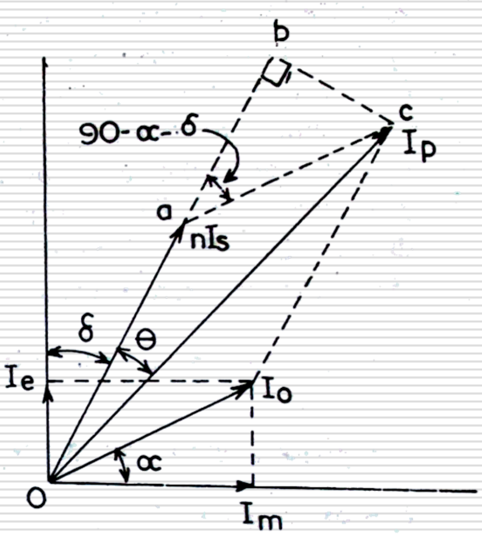
- **Nominal Ratio (K_n):**

$$K_n = \frac{\text{Rated Pri. Winding Current}}{\text{Rated Sec. Winding Current}}$$

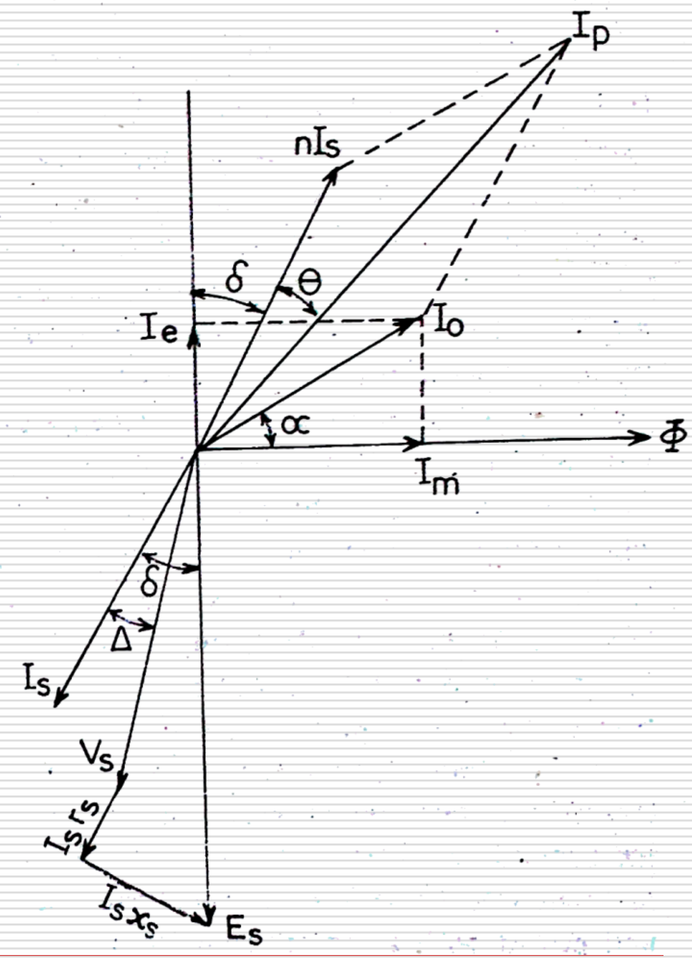
Errors in CT



Ip
rp
xp
Ie
Io
Im
Vp
Rc
Xm
Ep
Φm
Is
rs
xs
re
Vs
xe



b
c
90-α-δ
Ip
a
nIs
δ
θ
Ie
Io
α
O
Im



Ip
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Es

Errors in CT

$$\text{Ratio Error} = \left(\frac{K_n - R}{R} \right) \times 100\%$$

Construction

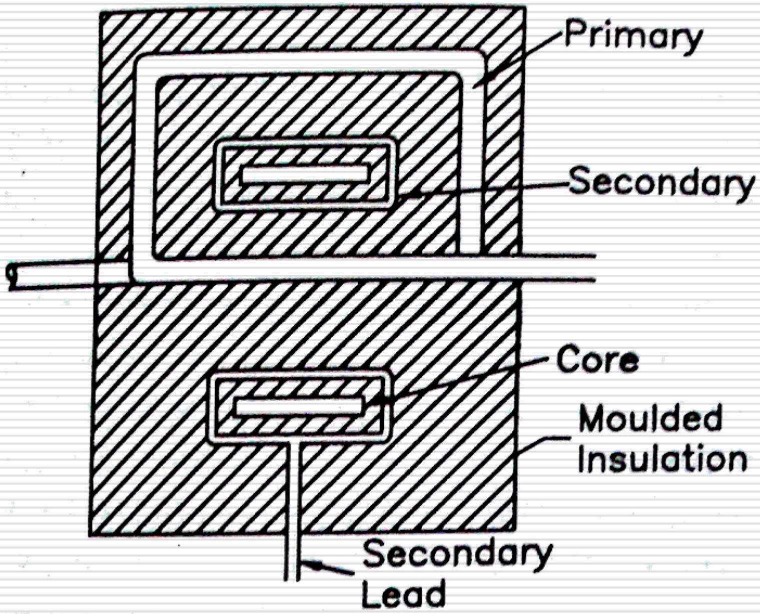

Fig. 17.3. Wound type current transformer.

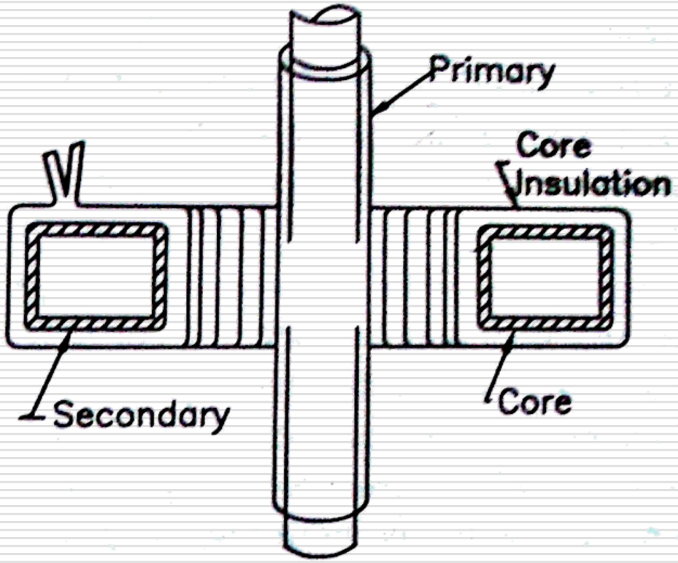

Fig. 17.4. Bar type current transformer.

Construction

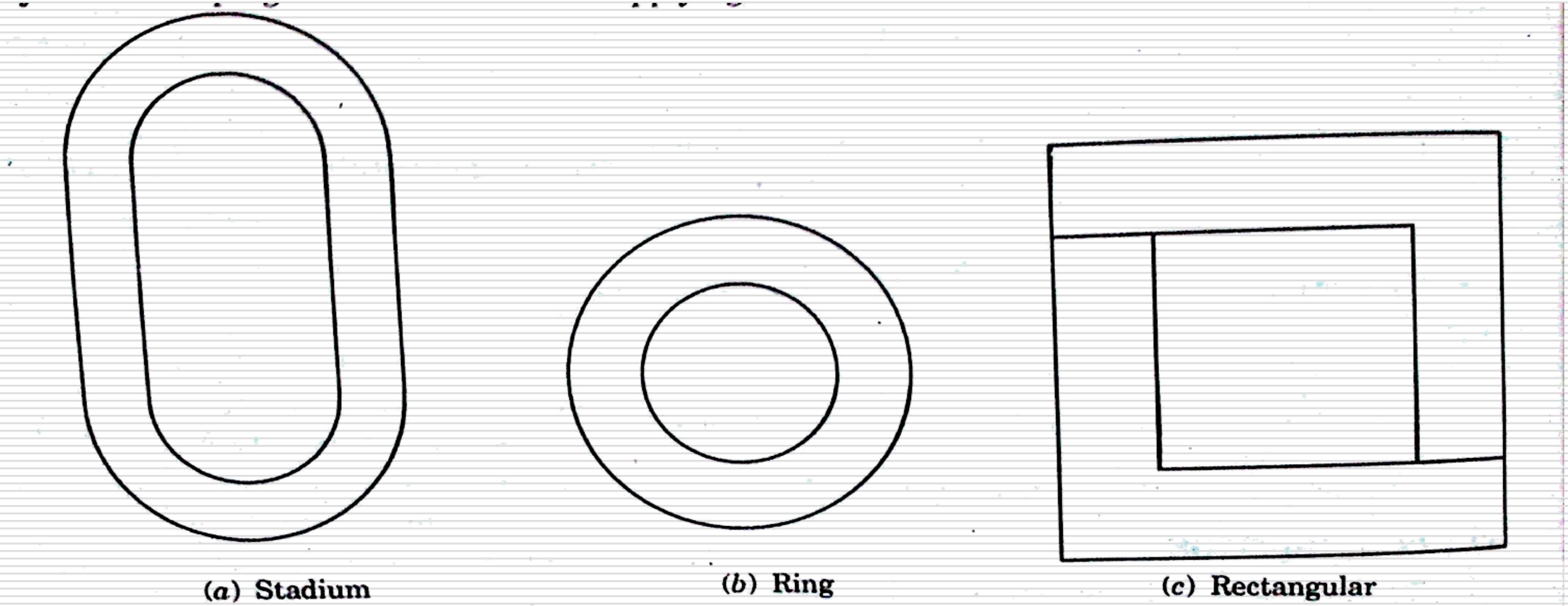

Fig. 17.5. Laminations for window type current transformers.

Construction

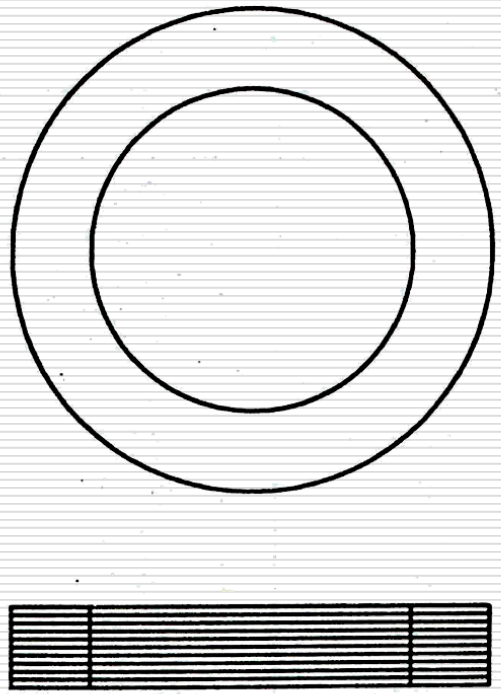

Fig. 17.7. Cylindrical stack.

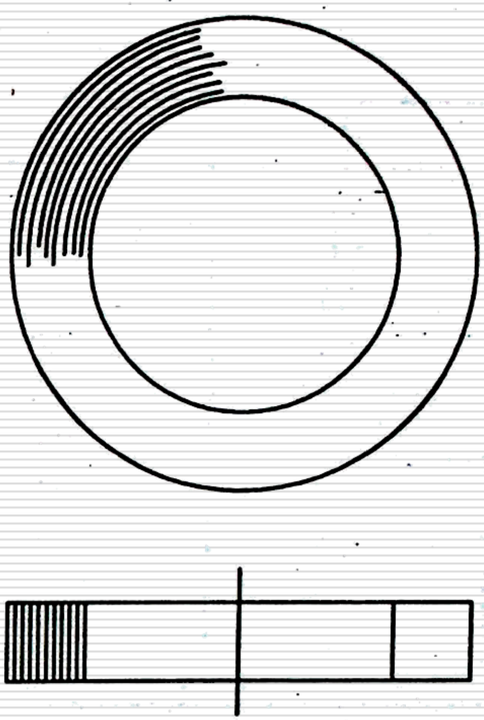

Fig. 17.8. Spiral core.

Construction

- Secondary Current Rating
  - 5 A, 2 A or 1 A

- Primary Current Rating:

Table 17.1. Rated primary current

A	A	A	A
0.5	0.0	100	1000
1.0	12.5	125	1250
2.5	15.0	150	1500
5.0	20.0	200	2000
	25.0	250	2500
	30.0	300	3000
	40.0	400	4000
	50.0	500	5000
	60.0	600	6000
	75.0	750	7500
		800	10,000

Construction

- Windings:
  - For 5 A Sec. Round copper wire 3 mm^2
  - Current Density =1 to 2 A/mm^2
  - Must withstand large short circuit current
  - Small rating
    - Insulated by tape and varnish
  - Large rating above 7kV
    - Oil immersed

Behaviour under System SC

System Short Circuit Current :

$$i = 2\sqrt{2}\,\frac{V_{ph}}{\in_z}\,I_p$$

Current to withstand :

$$i = 2\sqrt{2}x\,\frac{V_{ph}}{\in_z}\,I_p$$

V_{ph} = System Voltage/phase

$\in_z$ = p.u. impedance of system

I_p = rated primary current

Behaviour under System SC

- Temperature Rise
  - Not more than 200 °C

$$\theta = at\left[\frac{2T_1 + at}{2T_1} + \frac{620K_e}{2T_1 + at}\right] {}^\circ C$$

t = time, s ; $T_1 = \theta_1 + 235^\circ$;

θ_1 = initial temperature, °C

K_e = eddy current loss ratio at 75°C

$a = 0.0025 \times$ loss in W/kg at $\theta_1 = 1.9\ \delta^2 T_1 \times 10^{-5}$

δ = current density, A/mm^2.

Behaviour under System SC

- Current Density

Table 17.2. Current density under short circuit conditions

Rated time s	*Current density* A/mm^2
0.5	235
1.0	165
2.0	115
3.0	95

Behaviour under System SC

- Mechanical Forces

$$F_r = \frac{\mu_e}{2} (iT)^2 \frac{L_{mt}}{L_c} \text{ N.}$$

$$F_p = \frac{F_r}{2\pi} \qquad F_p = \frac{\mu_c}{4\pi} (iT)^2 \frac{L_{mt}}{L_c} \text{ N}$$

- Hoop Stress

$$P_p = \frac{F_p}{Sf\, b_p\, L_c} = \frac{\mu_c}{4\pi} (iT)^2 \frac{L_{mt}}{S_f\, b_p\, {L_c}^2} \text{ N/m}^2$$

Thank You